OUR FARMHOUSE . . .

HEATING

U. S. DEPARTMENT OF AGRICULTURE Miscellaneous Publication No. 689

Plan for Comfort

Heat escapes from a house whenever it is colder outside than inside. There are few houses in the United States that do not at some time need added heat. But there are ways to reduce the heat requirements.

When building a new house, consider the possibilities of solar orientation—facing the main rooms and the large windows in the main rooms to the south to take advantage of the winter sun that strikes the earth at a low angle (fig. 1). The summer sun, which is higher in the sky, can be kept out by long overhangs, by the use of trellises and vines, or by properly located trees. In cold climates large glass areas should be more than one pane in thickness or gains in heat from sunlight will be offset by night heat loss through the glass.

With a slow-acting heating system, solar orientation may result in periods of overheating and underheating. If the thermostat of an automatically controlled heating plant is in one of the rooms receiving solar radiation the rest of the house may be too cold. If the thermostat is placed elsewhere the solar rooms may be too hot, and no fuel will be saved unless radiators are turned off or warm-air ducts closed during the solar heating period.

Heat requirements are also reduced by tight construction, storm sash, weatherstripping, and insulation. It is good economy to repair and insulate an old house before installing a new heating system. (See Miscellaneous Publication 633, Your Farmhouse—Insulation and Weatherproofing.)

Shiny aluminum roofs reflect heat from the sun. Acting as reflective insulation, they keep the house cooler in summer. Although sun heat is not admitted to help warm the house in winter, less heat escapes from within the house and there is a net saving in fuel.

The chimney is practically a part of the heating plant and its size and height are important to efficient functioning of the system. Flue-lining sizes

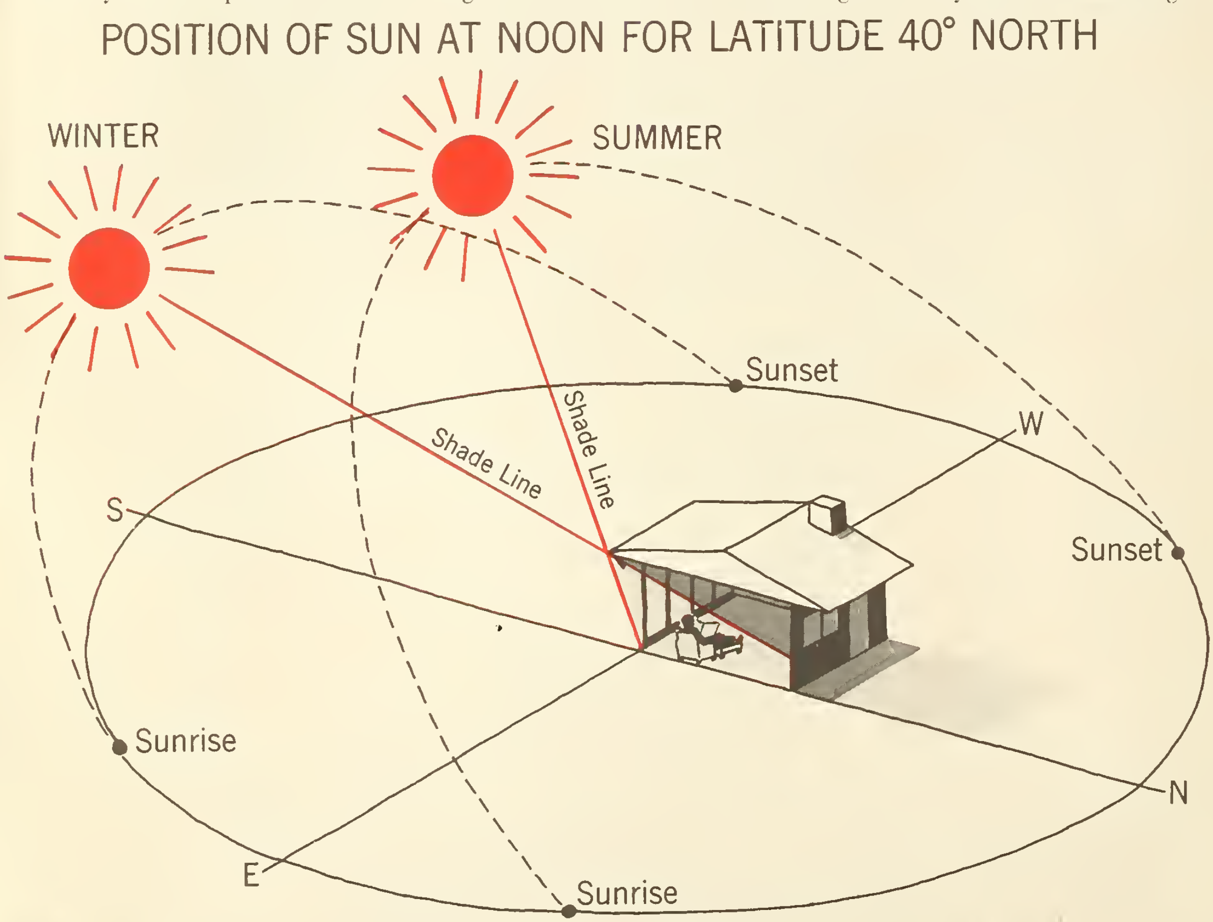

Figure 1.—Solar orientation.

based on the grate area of the stove, circulator heater, or furnace or boiler burning solid fuel, are as follows:

Grate area in square feet	Round (inside diameter)	Rectangular (outside dimensions)
	Inches	*Inches*
1	8	8½ by 8½.
2	10	8½ by 13.
3	10	8½ by 13.
4	12	13 by 13.
5	12	13 by 13.

Chimney heights are governed mainly by the height of the house. The chimney should extend above the ridge, but need not be more than 2 feet higher. Flues must be kept clean and free from leaks. The flue for the furnace or boiler should have no other openings below the top. For a fuller discussion of chimney design and construction, see Farmers' Bulletin 1889, Fireplaces and Chimneys.

There is no simple rule for estimating heat requirements, but experienced local dealers and contractors usually have information that will help you decide what size and type of heating equipment you need.

For safety and efficiency have a competent, experienced heating contractor install your central heating system, especially any automatic equipment, and inspect it once a year. A less costly heating system correctly installed will be more satisfactory than an expensive one that is not the right size for the house or not properly installed.

Heat is transferred by conduction, convection, and radiation. When you burn your hand on a hot pan handle, that is conduction. When you feel hot air coming from an open oven door, that is convection. When you feel the heat of the sun even though the air is cool, that is radiation.

Warm-Air Heating

The fireplace and the cook stove or range are two of the simplest heating devices, and they are used a good deal, especially in the South. A coal- or wood-burning range often furnishes all the heat needed in a farm kitchen. Fireplaces are enjoyable, but they are not efficient sources of heat. They may be used to supplement other heating equipment and to take the chill off the house when it is not cold enough to start the furnace. Modified fireplaces now available are more efficient because warm air is discharged from air ducts surrounding the fireplace (fig. 2). Farmers' Bulletin 1889, Fireplaces and Chimneys, gives the principles for building safe, satisfactory fireplaces.

Stoves are more effective room-heating devices than fireplaces. They radiate heat from all sides and the top and less of it goes up the chimney. Although less expensive than central heating systems, they are dirtier, require more attention, and heat less uniformly. Several stoves may be used but with more than one stove you may need more than one chimney.

Wood- or coal-burning stoves for room heating have become more modern in appearance. Those without jackets heat principally by radiation. Jacketed stoves or circulator heaters (fig. 3) heat

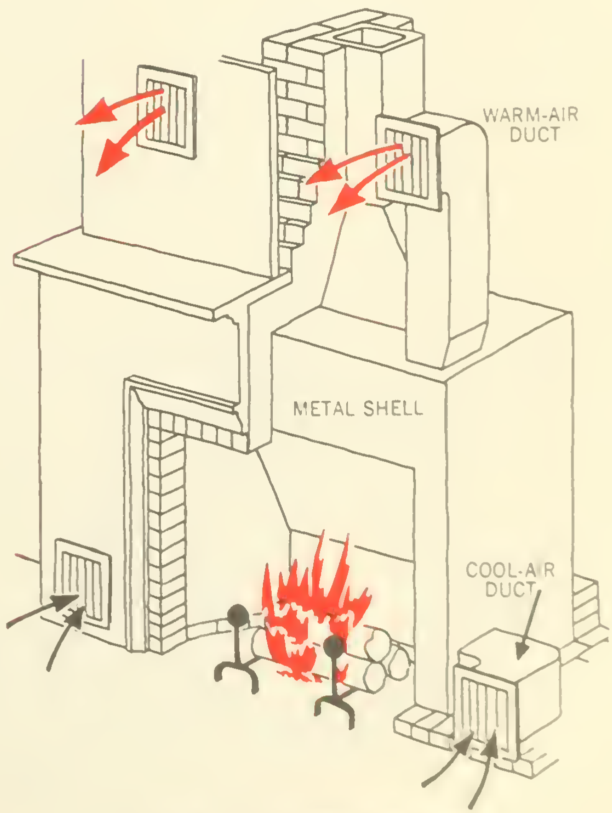

Figure 2.—Modified fireplace.

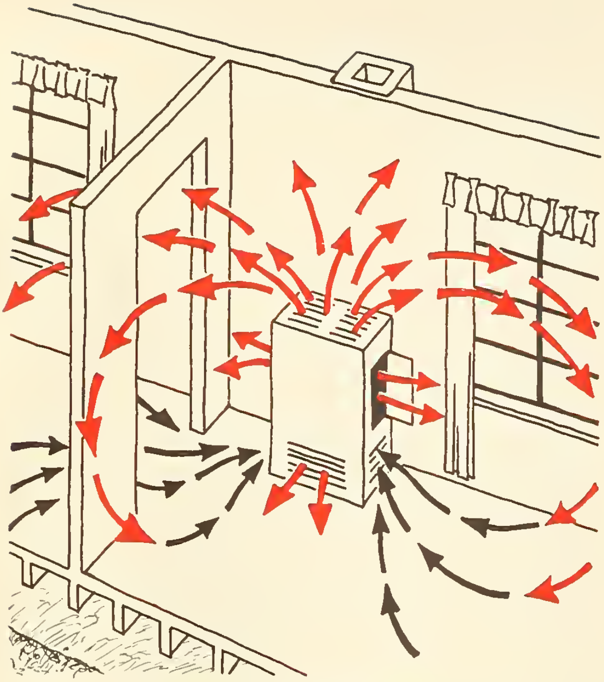

Figure 3.—Circulator heater.

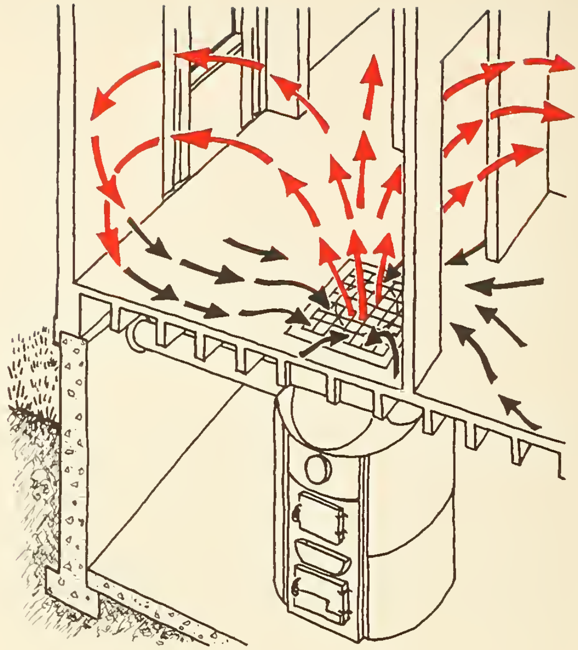

Figure 5.—Pipeless furnace.

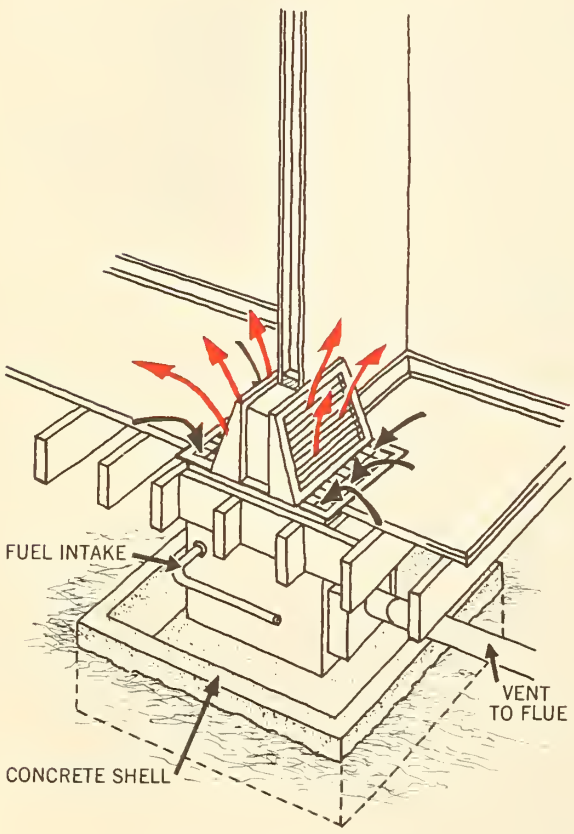

Figure 4.—Floor furnace.

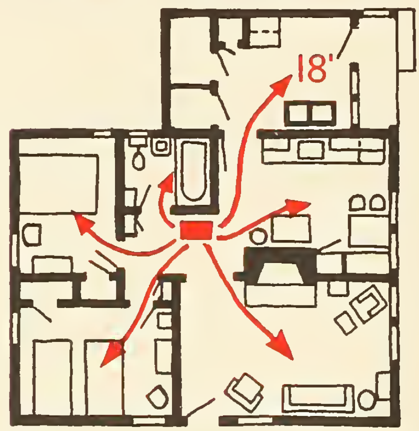

Figure 6.—Good floor plan for ductless heating.

mainly by convection—movement of warm air currents. They are available for burning wood, coal, oil, or gas.

In a circulator heater, air circulates between the stove and the jacket, which has openings at top and bottom. With proper arrangement of rooms and doors, a circulator heater may heat four or five small rooms. The distance from the heater to the center of each room to be heated, measured through the door, should be not more than 18 feet. The heated air should reach each room through only one door. Unless doors are left open they must have grilles or louvres at top and bottom for air circulation.

Another type of heater that is popular for one-story basementless houses is the oil- or gas-burning floor furnace (fig. 4). Suspended from the floor, this unit requires only a dry pit and a suitably framed floor opening and vent or chimney connection. The pit should be large enough to allow at least 1-foot clearance from sides and below furnace. A single floor furnace will heat four or five rooms.

With a basement, a pipeless furnace can be used (fig. 5). It has one register placed directly over the furnace and is satisfactory for heating small one-story houses. Pipeless furnaces are available for burning the four common fuels.

Circulator heaters, floor furnaces, and pipeless furnaces heat the house without benefit of pipes or ducts to carry warm air to the separate rooms. Size and arrangement of rooms and placing of doors are therefore important for satisfactory, uniform heating. The suggested floor plan shown in figure 6 is designed for efficient use of this type of heating equipment.

A furnace is made of cast iron (fig. 7) or steel (fig. 8) and consists of a base, fire pot or hearth, combustion dome, and radiator. When solid fuels fired by hand are used, an ash pit and grate (fig. 7) must be included. These parts are surrounded by a galvanized-iron or enameled jacket on top of which is the bonnet. Air passes through the space between the fire pot wall and the outer shell, or jacket, receiving heat as it moves over the hot fire-pot walls. It is essential that the fire pot (combustion chamber) be tight to prevent the escape of smoke and gases. Air for burning may move through the furn-

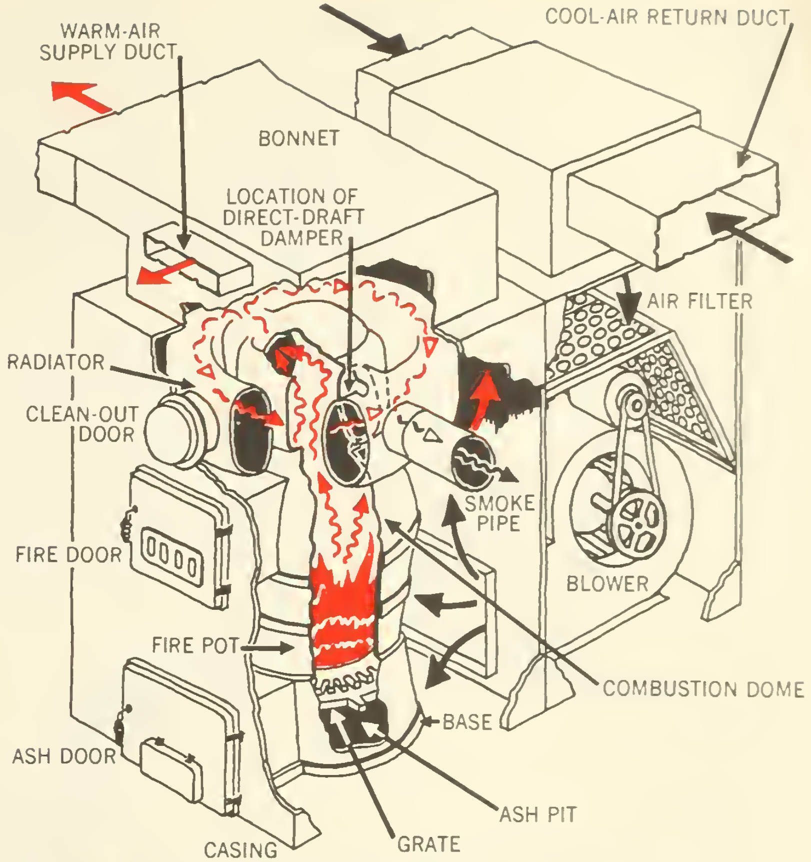

Figure 7.—Cast-iron furnace with blower.

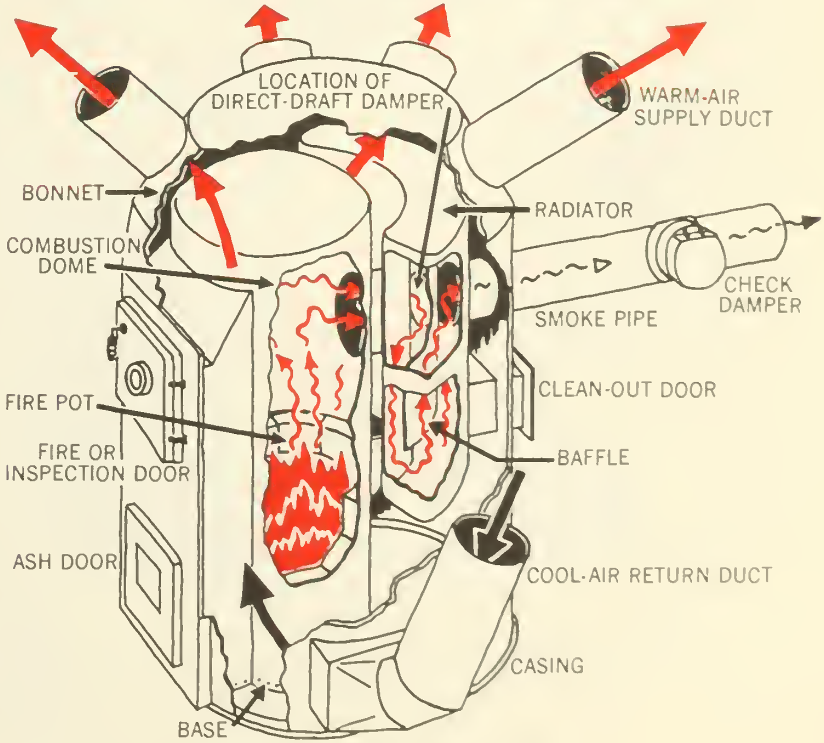

Figure 8.—Steel furnace.

ace by the chimney draft or it can be forced through with a fan.

Whether you are buying a circulator heater, or a furnace or boiler for a central heating system, it is always best to buy equipment designed specifically for the fuel to be used. Coal or wood burners can be converted to oil or gas but usually do not have sufficient heating surface for best efficiency. Because of the larger fire pot required for coal or wood, conversion of oil- or gas-burning equipment to solid fuels is not satisfactory. If you are going to burn oil but think you may later want to convert to solid fuel, it is wise to buy a coal-burning unit to start with. In this case a unit with large heating surface should be selected.

Warm-Air Central Heating Systems

Gravity Warm Air.—A gravity warm-air system consists of a furnace from which ducts extend to the rooms to be heated. These ducts carry the warm air that is discharged into the rooms through registers. Another series of grilles and ducts carries cooled air back to the furnace (fig. 9). The circulation of air depends on the difference in weight between warm and cool air. Warm air rises because it is light and cool air falls because it is heavier. For this reason the furnace of a gravity warm-air system must be located below the lowest room to be heated.

Registers for the gravity warm-air system are placed in or near the baseboard, preferably on inside walls. Floor registers are not ordinarily recommended in new construction but are often used when installing new furnaces in existing houses. It is sometimes a good idea to put a small piece of furniture, such as a magazine rack, in front of a warm-air register to break the air stream and distribute the heat better.

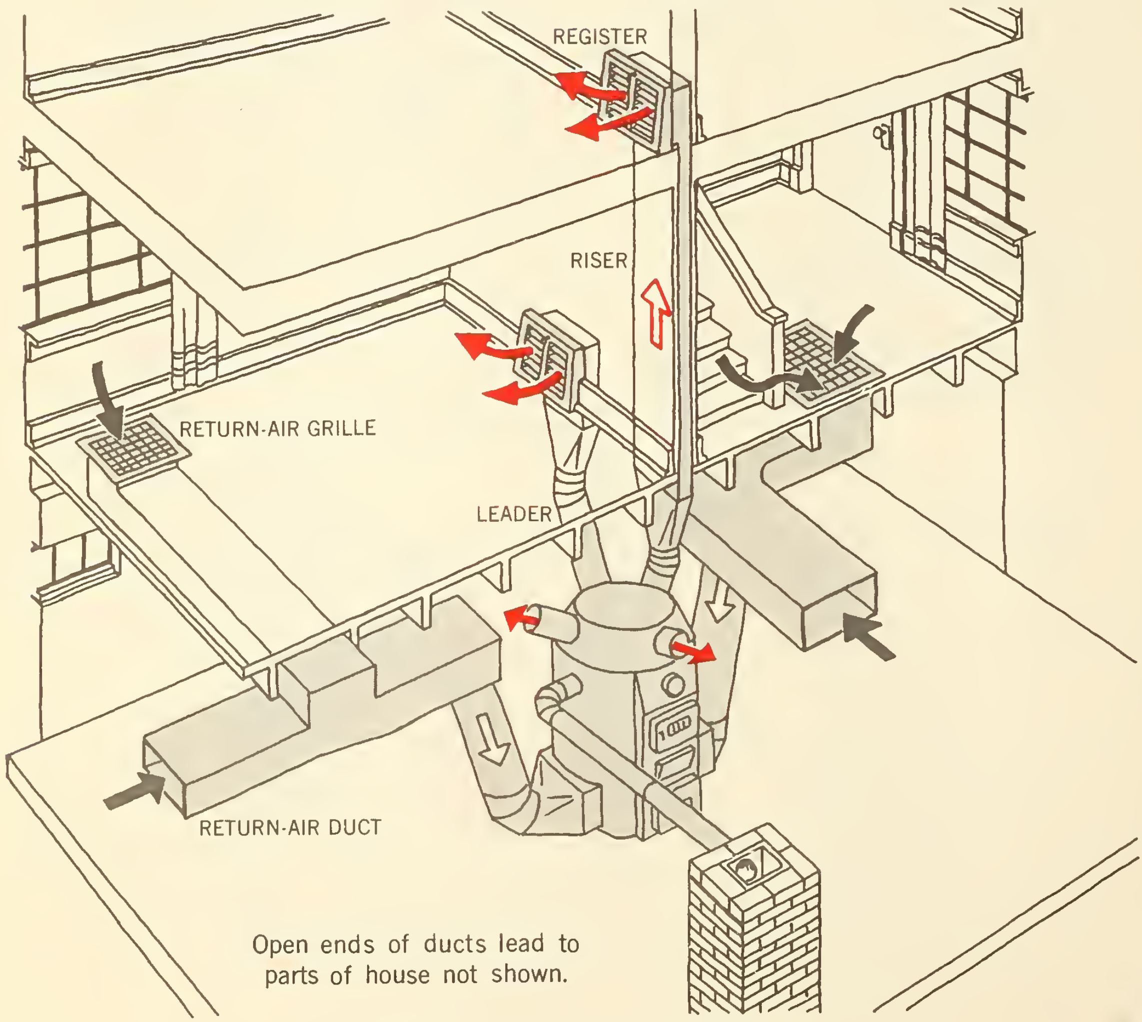

Figure 9.—Gravity warm-air system.

Grilles over the intakes of return-air ducts are usually in the floor and should be removable for cleaning. Do not put rugs or low furniture over them.

The ducts carrying warm air from the furnace to first-floor registers and to risers extending to the second floor are called leaders. All leaders should be as short and as nearly the same length as possible, and all return ducts as nearly the same length as possible. The furnace, therefore, should be placed under the center of the house.

The gravity warm-air system is probably the cheapest central heating system. It responds quickly to changes in heat demands when properly fired and regulated, and there is nothing about it to freeze when not in operation during cold weather. If the warm air is too dry, moisture can be added by hanging an evaporating pan inside the furnace jacket. A relative humidity of at least 30 percent is recommended for comfort. An air filter cannot be used satisfactorily with this type of system.

Forced Warm-Air.—Warm-air systems with forced circulation (fig. 10) are more expensive but they have certain advantages. The furnace does not have to be below the rooms to be heated, nor centrally located, because circulation of air is controlled by a fan or blower (fig. 7). The greater air pressure means that an air filter can be used, ducts may be longer and narrower, may run horizontally, and need not be all the same length. Return-air grilles can be placed in the baseboards.

Registers can be near the ceiling (allowing more freedom in placing furniture), low in the wall, or in the baseboard. They should be placed so air won't be blown against people in the room. When registers are near the ceiling, the vanes should deflect the warm air slightly downward and sideways.

The other main kind of central heating is by hot water or steam that is piped through the house and warms the rooms by radiation and convection.

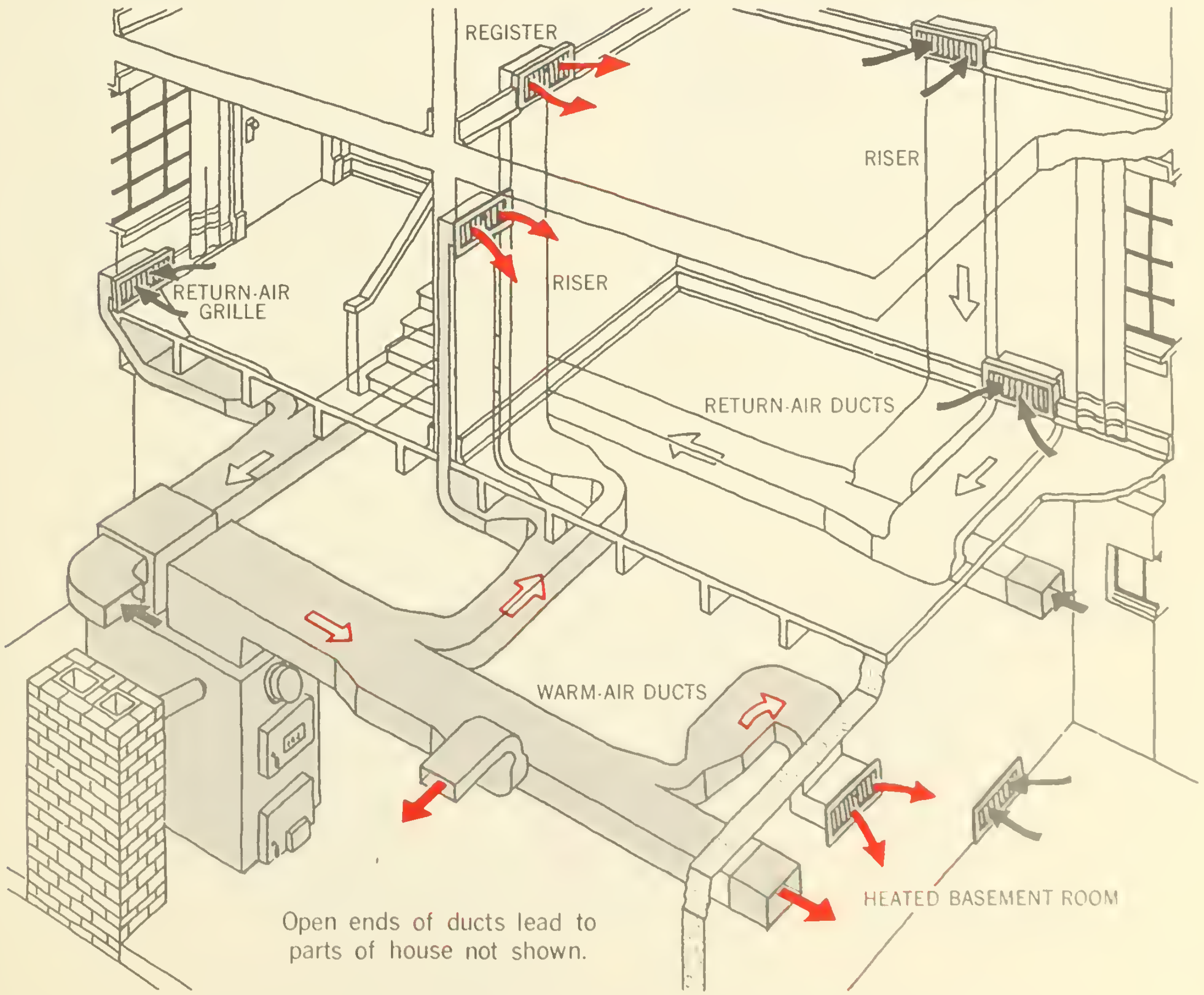

Figure 10.—Forced warm-air system.

Hot-Water and Steam Heating

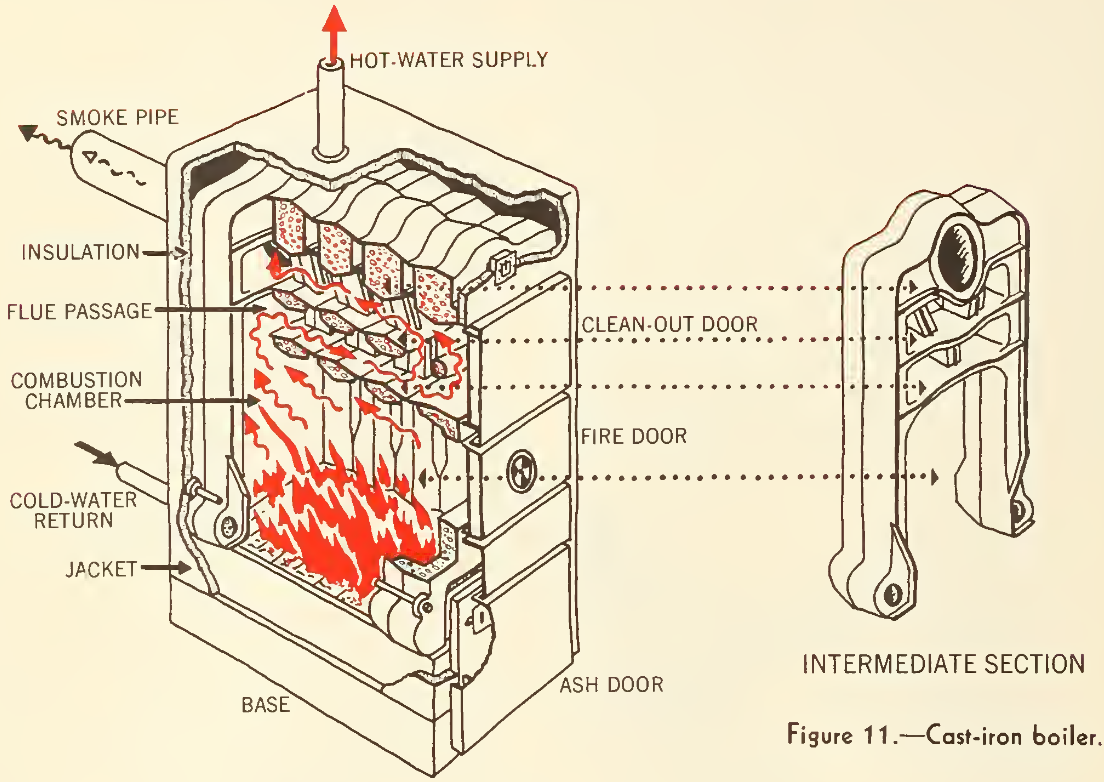

Figure 11.—Cast-iron boiler.

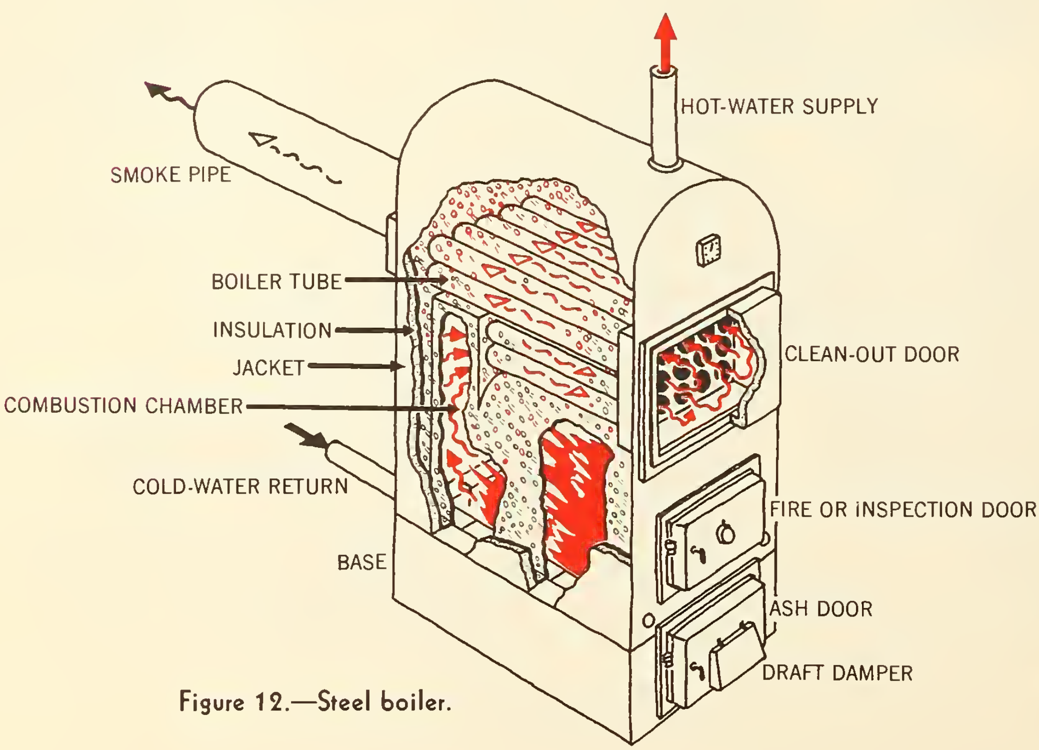

Figure 12.—Steel boiler.

Hot-Water and Steam Central Heating Systems

All hot-water, steam, or vacuum heating systems require a boiler instead of a furnace. Boilers are made of cast iron (fig. 11) or steel (fig. 12) and are designed for different fuels. These generalized pictures do not show all the dampers needed on a boiler equipped for burning any specific fuel.

The most efficient boilers have long flues, baffles, or other means of holding the gases until they are practically all burned and the maximum amount of heat is transferred to the water. Some boilers have a fire travel of nearly 3 times the length of the boiler.

Boilers of cast iron are more bulky than those of steel but it is claimed that they are more resistant to corrosion. The quality of the water is likely to affect the two materials differently. Investigate the experience of other people in the neighborhood who use the same water. Corrosive water can be corrected by chemicals. These chemicals are furnished with many steel boilers as standard equipment. By proper water treatment, the life of steel boiler tubes, which are usually first to need replacement, can be greatly prolonged. Replacement of tubes is easier if they are rolled in rather than welded.

When you buy a boiler look for the rating stamp. Cast-iron boilers are stamped I-B-R (Institute of Boiler and Radiator Manufacturers) and steel boilers SBI (Steel Boiler Institute). Choose a boiler with a net rating suitable for the heating job it has to do.

You can now buy a boiler in a package unit complete with controls, firing equipment, and accessories. For small houses such a unit may include radiators, piping, and valves as well. It is usually best to have an experienced heating man install the system.

Radiators or convectors are used to distribute the heat from hot water and steam. They are connected to the system in the same way and all mention of radiator pipes and valves applies also to convectors.

Radiators are usually made of cast iron. They may be located on the floor, preferably under a window (fig. 13), mounted on the wall, or recessed partly or wholly into the wall. If the radiator is recessed into the wall, it is important to put insulation behind it. Use at least one inch of rigid insulation or a sheet of reflective insulation, or better still, use both. A shield over the top will divert air currents away from the wall and help prevent dirt streaks.

A cabinet may be put around the radiator, but it should have openings at bottom and top for air circulation and should be easy to remove for cleaning. Painting radiators with metallic paints, such as aluminum or bronze, makes them less effective.

Convectors usually consist of finned tubes through which the hot water or steam is circulated. They are either recessed (fig. 14) or boxed with openings at the bottom and top of the enclosure.

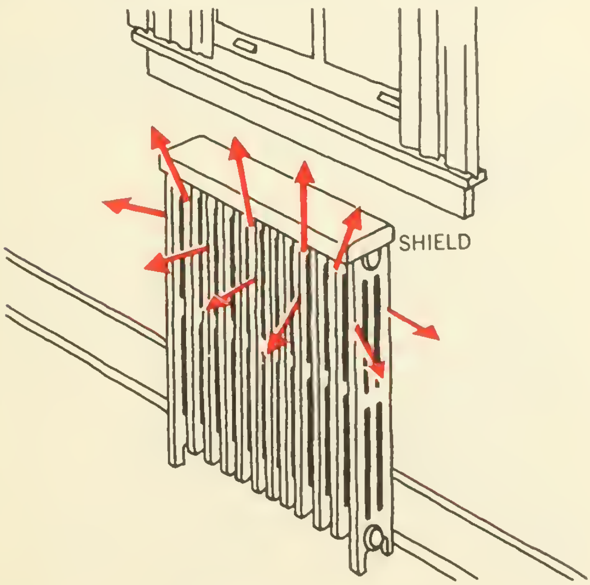

Figure 13.—Radiator.

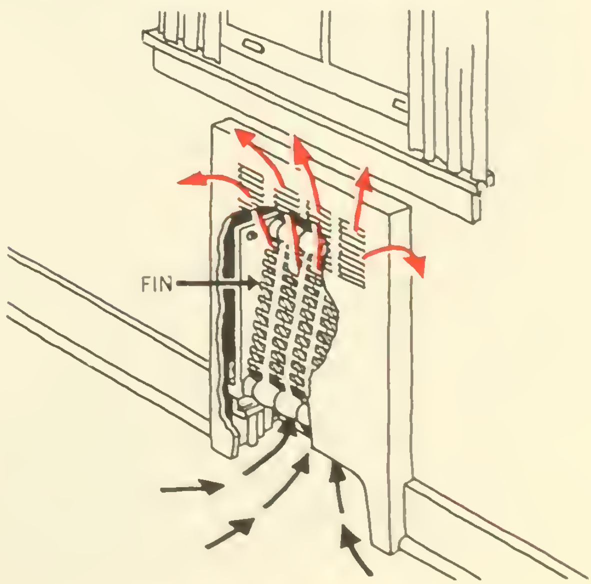

Figure 14.—Convector.

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The coils of finned tubes warm the air that comes in at the bottom and goes out at the top. The heating surfaces are not exposed to the room.

The new baseboard radiator (fig. 15) is a hollow unit designed to look like a baseboard, which it replaces along outside walls. Tests show it to be an effective way to heat a room uniformly, with little temperature difference between floor and ceiling.

Gravity Hot Water.—Hot-water systems like warm-air systems may be either gravity or forced circulation. Cool water is heavier than hot water, just as cool air is heavier than warm air. Water heated in the boiler becomes lighter and rises as the heavier, colder water of the heating system moves in to lift it. As this process continues in the boiler, hot water circulates through the pipes and radiators.

Fresh water is fed into the heating system as needed from the water system through a hand valve. Enough pressure is maintained so that the highest radiator is filled with water.

The gravity hot-water system (fig. 16) usually has two main pipes, one to supply hot water from the boiler to the radiators, and one for the return of cool water. A riser from the hot-water main is connected to one end of each radiator and a riser from the return main to the other end. In the gravity system the boiler must be located below the lowest radiator.

Any air in the hot-water system will find its way to the highest parts of the system and collect in the tops of the radiators, preventing the tops from getting hot. Circulation may be choked off entirely in the gravity system if there is a high point where air can collect. Install pipes with some slope and let air out of the radiators occasionally by opening the air-vent valves.

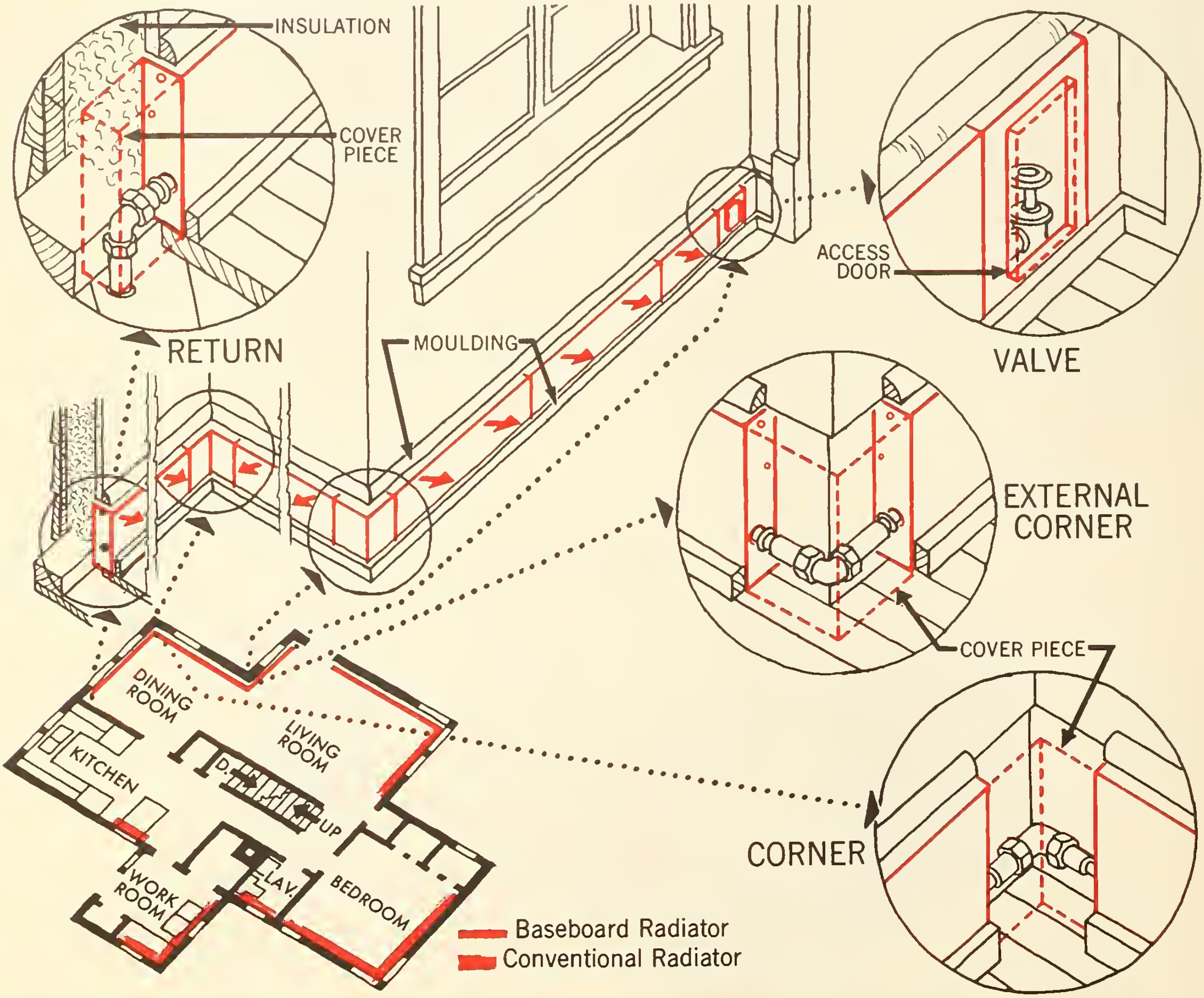

Figure 15.—Baseboard radiator.

Because water expands when it is warmed, an expansion tank must be provided. Sometimes the tank is located above the highest point in the system and has an overflow pipe extending through the roof. In this open system, the tank and overflow pipe must be protected from freezing.

A closed system has a closed expansion tank placed anywhere in the system, usually near the boiler. About half of the closed tank is filled with air, which compresses when the heated water of the system expands. The closed system allows for higher water pressure than the open. This raises the boiling point of the water. Higher temperatures can be maintained without steam in the radiators, so smaller radiators can be used. There is almost no difference in fuel requirements.

In the closed system a pressure-reducing valve installed in the water-supply line between the hand valve and the boiler maintains proper pressure in the system, and a pressure-relief valve takes care of too great pressure increases (fig. 16). If the pressure-relief valve discharges water every time the boiler starts to heat, the expansion tank is probably waterlogged—completely filled with water, leaving no space for air.

To remove the water from the expansion tank without draining the entire system: (1) Close the water-supply hand valve; (2) open the drain cock at the bottom of the boiler; (3) remove the plug at the end of the expansion tank. As soon as the tank is empty replace the plug, close the drain cock, and open the water-supply hand valve. The pressure-reducing valve will let in the right amount of water. Then let air out of the radiators.

Forced Hot Water.—In a one-pipe or two-pipe forced-circulation, hot-water system, a small circulating or booster pump (fig. 16) aids the movement of the water, so that response to temperature changes in the house is faster. In the one-pipe system the water main makes a complete circuit

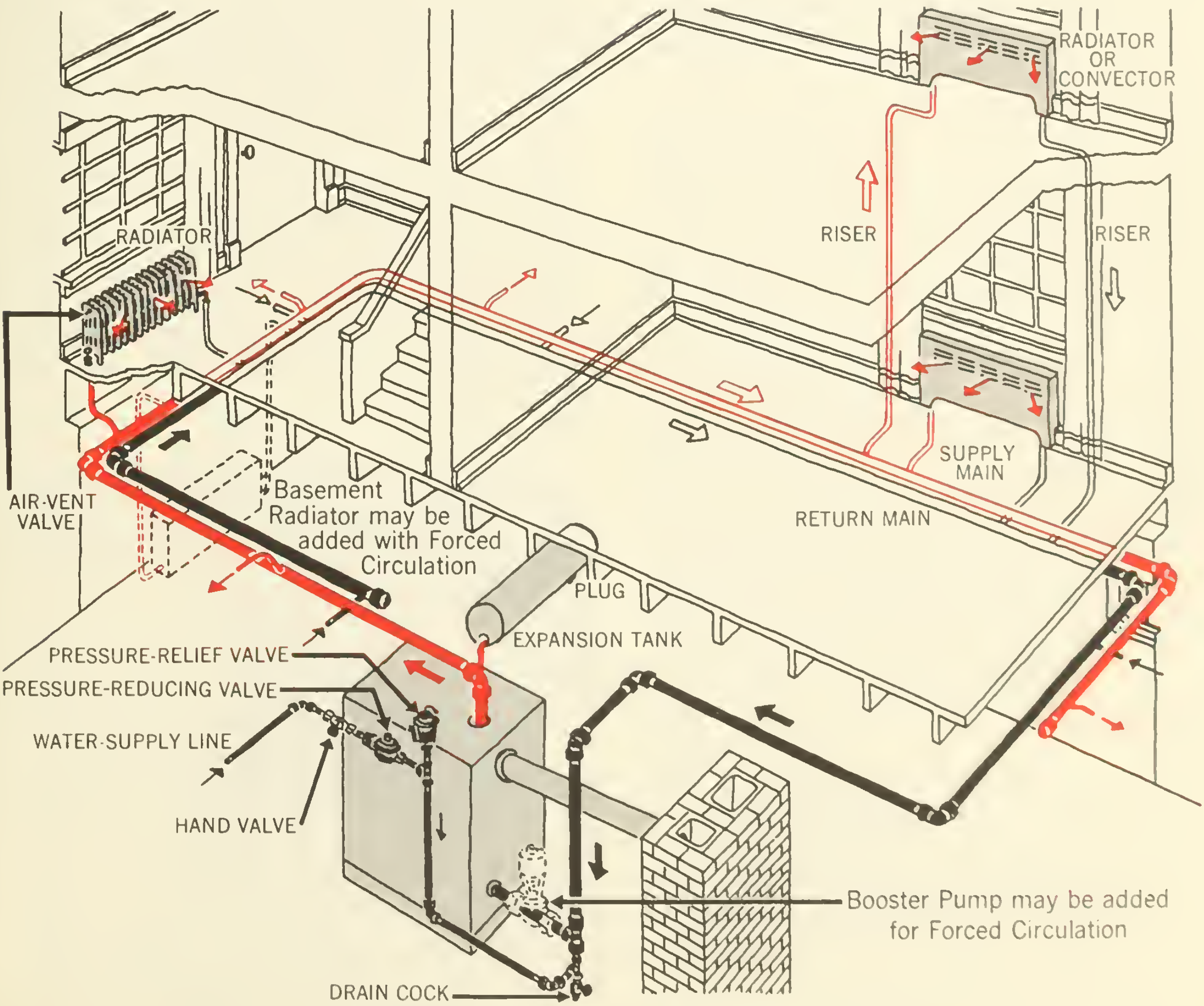

Figure 16.—Hot-water system.

from the boiler and back again. Two risers extend from the main to each radiator. Water is diverted through the radiator by means of a scoop fitting or other device.

The one-pipe system takes less pipe than the other, but it has a disadvantage. Some of the water that has passed through one radiator and cooled down is mixed with the water flowing through the main, so that each succeeding radiator receives cooler water. Allowance for this must be made in choosing the right size for radiators—a job for an experienced heating engineer or contractor.

The pump, motor, and controls of a forced-circulation system add to its cost over a gravity system, but smaller pipes can be used and it is less necessary to insulate them than it is the larger pipes of the gravity system. This may offset the cost of pump and controls. Since radiators can be located lower than the boiler, and pipes need not slope, the forced system can be used in basementless houses. Provision must be made for drainage of low places in the system.

With heating coils installed in the boiler or in a water heater connected to the boiler (fig. 31), year-round domestic hot water can be had. Although almost any heating system can be used to heat domestic water during the heating season, forced hot water or steam heat is the most satisfactory for year-round hook-ups. If you want to use your heating plant to heat domestic water, consult your heating engineer about the best arrangement.

Steam.—Steam heating systems, used less often in small farmhouses, can also be one pipe or two pipe. The one-pipe system is about as economical to install as the one-pipe hot-water system. Since steam is either on or off, it is less responsive to changes in heat demands. At the return end of each radiator or other heating unit is an automatic steam trap to keep live steam in the radiators and allow the water from condensation to drip back into the return pipes. The thermostatic type of steam trap is recommended for house-heating systems.

The two-pipe steam system usually costs more to install than the one pipe. Similar, but operating at much lower pressure, is the vacuum system. In either the steam or vacuum system the heating plant must be below the lowest radiator, unless a pump is used to return to the boiler the water condensed from the steam.

Installation of any of these systems requires specialized experience with the particular type of heating.

Panel Heating.—A new method of heating with forced hot water, steam, or electricity is panel heating. It has the advantage of warming persons in the room without raising the air temperature as high as is necessary for comfort with other heating systems. The room temperatures are more uniform, and no valuable room space is taken up by radiators. It is used more often with hot water than with steam or electricity.

In panel heating (fig. 17), the floors, walls, or ceilings are kept hot enough to act as radiators. Usually 80° to 85° F. is considered the maximum mean temperature for bare floor panels. Near walls it may be allowed to reach 90°. If rugs are used, the temperature may be higher. Corridor or hallway floors may be heated to 95°. Ceiling temperatures are governed by ceiling heights. The temperature of an 8-foot ceiling should not be much above 100°. Panel heating in ceilings is not considered practical unless you want heat in the space above.

When panels are heated with hot water the surface directly over the pipes will be warmer than the surface midway between them. Pipes should be so spaced as to avoid temperatures more than 8° to 10° F. above or below the average. Panel-heating systems should be designed by experienced heating engineers.

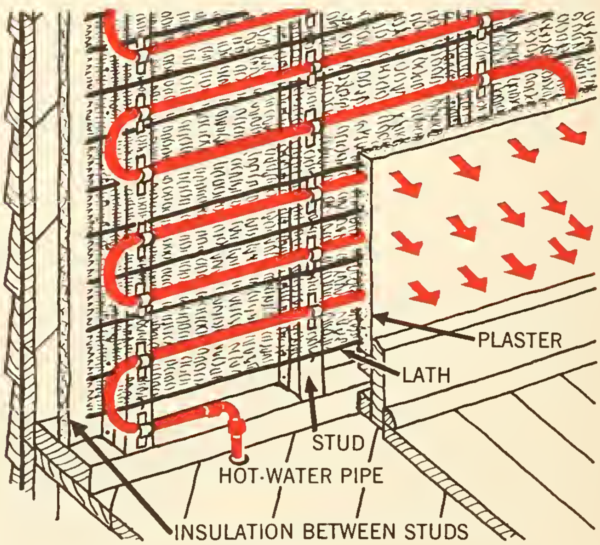

Figure 17.—Panel heating.

Fuels and Burners

The four fuels in common use for home heating are wood, coal, oil, and gas. Coke and dried peat are used in some parts of the country. Electricity, though scarcely a fuel, is heating many homes. Modern heating equipment is relatively efficient when used with the fuel for which it is designed, but even with modern equipment some fuels cost more than others to do the same job.

Comparing Fuel Costs

The Small Homes Council of the University of Illinois has developed a method of comparing heating costs. Table 1, adapted from their Circular Series G3.5, is the basis for working this out.

TABLE 1.—*Comparison of costs of coal, oil, and gas for a given heating job, worked out by Small Homes Council, University of Illinois.*

Fuel	Heat value		Price per unit [1]	
	B.t.u. per unit			
			Dollars	
Gas	100,000	Therm	0.075	Therm.
Oil	140,000	Gallon	[2] .105	Gallon.
Do	140,000	do	[3] .092	Do.
Bituminous coal.	12,000	Pound	[4] 12.37	Ton. (2,000 pounds)
Do	13,000	do	[4] 13.42	Do.
Do	14,000	do	[4] 14.40	Do.
Do	12,000	do	[5] 14.62	Do.
Do	13,000	do	[5] 15.82	Do.
Do	14,000	do	[5] 17.00	Do.
Anthracite	12,500	do	[4] 15.22	Do.
Do	13,500	do	[4] 16.42	Do.
Do	12,500	do	[5] 18.75	Do.
Do	13,500	do	[5] 20.25	Do.

[1] At these prices the different fuels give the same amount of heat per dollar.

[2] Heating unit designed for oil burning.

[3] Heating unit converted to oil burning.

[4] Hand-fired without automatic controls.

[5] Hand-fired with automatic controls or stoker-fired.

How to use the table: Obtain the heating value of coal (B. t. u. per pound) from your fuel dealer. For cost of gas per therm, divide the local market price per 1,000 cubic feet by the number of therms per 1,000 cubic feet. The numbers of therms per 1,000 cubic feet of gas are as follows:

Manufactured gas	5 to 7
Natural gas	10 to 11
Butane gas	33.9 (approximate)
Propane	25.7 (approximate)

Select any fuel and proceed as follows:

(1) Determine its local price.

(2) Divide the local price by the price per unit in the table.

(3) Find in the table the unit cost of the fuel you wish to compare.

(4) Multiply this value by the result obtained under (2). The product is the price at which you will buy the same amount of heat per dollar as with the first fuel.

(5) Compare the price for the second fuel obtained under (4) with the local price for that fuel.

Example: Suppose you want to compare 13,000-B. t. u. bituminous coal with oil. If the price of 13,000-B. t. u. coal is $15 per ton, at what local price per gallon will oil be cheaper for the same heating job?

(1) In the table you will find a price per unit for 13,000-B. t. u. coal of $13.42 per ton if fired by hand, or $15.82 if fired with a stoker. If you are using a stoker, you will select the $15.82 value.

(2) Divide 15.00 by 15.82 and obtain .948.

(3) Now find in the table a value of $0.10½ per gallon for oil for use with a unit designed to burn oil and $0.092 for oil burned in a converted unit. For a converted unit:

(4) Multiply 0.092 by .948 and obtain $0.0872+ or approximately 8.72 cents.

If oil costs more than 8.72 cents per gallon, it will be cheaper to burn the $15 coal. If oil costs less than 8.72 cents per gallon, it will be cheaper to heat with oil.

This comparison does not take into consideration the cost of the heating plant or of the electric power involved. Other factors besides cost, of course, are often to be considered in choosing a fuel.

Wood

Wood is on the farm or close at hand in many sections of the country. It is bulky and requires more labor and sometimes more storage space than other fuels, but wood fires are easy to start, burn with little smoke, and leave little ash.

Most well-seasoned hardwoods have about half as much heat value per pound as good coal. A

cord of hickory, oak, beech, sugar maple, or rock elm weighs about 2 tons and will have about the same heat value as 1 ton (2,000 pounds) of good coal. Cord-wood lengths are 4 feet, and a cord is usually measured in ricks 4 by 4 by 8 feet.

Coal

Two kinds of coal, anthracite (hard coal) and bituminous coal (soft coal) are used as fuels for heating homes. Most anthracite comes from a relatively small region in eastern Pennsylvania, so shipping costs limit the area in which it is used. Bituminous coal is found in widely scattered areas almost all the way across the country. Both anthracite and bituminous coal vary in volume for a given weight. Forty cubic feet per ton is ample storage space for any coal.

Anthracite burns with a clean, smokeless and sootless flame. It is available in a wide variety of sizes. Egg is the largest, and is much larger than a hen's egg. It is about 3 inches in diameter and must pass over a screen with 2 7/16-inch mesh and through a screen with 3 1/4-inch mesh. Next in order are stove, nut (or chestnut), pea, and buckwheat, with rice (or No. 2 buckwheat) the smallest. Rice is about 1/4-inch in diameter and must pass over a screen with 3/16-inch mesh and through a screen with 5/16-inch mesh. Bituminous coal sizes are not standardized nationally. The term "slack" also has variations in meaning but in general refers to powdered or very fine coal.

There is little difference in the heat value of the different sizes of coal, but certain sizes are better suited for burning in fire pots of certain sizes and depths (table 2).

Table 2.—*Recommended sizes of anthracite for different fire-pot dimensions*

Coal size	Fire pot	
	Diameter	Depth [1]
	Inches	*Inches*
Egg	24	16 or more
Stove	18 to 23	12 to 16
Nut	Less than 16	Less than 12
Pea	[2]	[2]
Buckwheat	Any	Shallow [3]
Rice	[4]	[4]

[1] Fire-pot depth is the depth from bottom of fire door to top of grate.
[2] Larger than would normally be used for area to be heated. Pea anthracite can also be used in a kitchen range.
[3] Buckwheat coal requires a tall chimney, 50 or more feet, for natural draft.
[4] Use with mechanical stoker.

Coarse fuel is hard to keep burning in small fire pots, but it can somewhat compensate for poor drafts in larger ones. In general, the depth of fuel regulates the flow of air through the fuel bed.

Finely broken coal must be used in shallow fuel beds, but by using a fan to furnish additional draft, small-sized coal can be burned in deep fire pots. Sometimes the air is blown into the ash pit or base and up through the grate. Use only enough air to make the fire burn well. If a fan is installed, it is a good idea to remove the latch from the fire door and use a spring to hold it shut.

Hand firing coal.—Never use kerosene, gasoline, or other explosive to start or revive fires.

During the day the fire is controlled by means of the draft and check dampers. Leave the fire-door damper slightly open at all times.

The fire will need banking for the night. Remove ashes from pit; shake grates until red glow appears; add coal; close draft damper and open check damper. Too much ash in the pit will reduce the draft and may cause burning or warping of the grate. Too much ash on top of the grate will also reduce the draft but a little will help prevent burning of the grate. Close the fire door but leave the fire-door damper open. You may pour water on the ashes in the ash pit just after shaking the grate.

A magazine- or hopper-type anthracite burner maintains the fuel bed at a constant depth and burns the coal evenly. As the coal is burned in the fire pot more flows down from the hopper. A charge of fresh coal in the magazine lasts about 24 hours under average conditions. The hopper or magazine door must fit tight to prevent drafts that might allow coal to burn in the hopper.

In banking a soft-coal fire do not cover hot coals completely. Smothering live coals with fresh coal, especially fine coal or slack, will result in excessive smoke and soot. Besides there is danger of an explosion and danger of carbon monoxide poisoning.

Stoker firing.—Either anthracite or bituminous coal can be fired mechanically. Manufacturers give complete instructions with their equipment. Follow these instructions. Most stokers now on the market use screw feeds. Air for burning is forced by a fan through openings (tuyeres) in the retort. The coal must be of relatively fine size. With anthracite, which does not clinker, the ashes are pushed out over the rim of the retort. They fall into the ash pit or are collected in cans.

There are two kinds of stokers for bituminous coal. In one of these (fig. 18) the ashes are fused into clinkers by the hot fire. The clinkers must be broken from the fuel bed with a poker and removed through the fire door or inspection door with tongs. Allow the clinkers to become fairly large before taking them out. The second type of stoker (fig. 19) has a revolving grate and a revolving ash table with a fixed scraper. The fine ash is not fused into clinkers but passes through holes in the grate. It is scraped off the revolving ash table into a screw conveyor that takes it to a tightly covered, removable ash can.

Stokers are available for firing either from a hopper (fig. 18) or from the coal bin (fig. 19). The hopper can be closed tightly to prevent smoke from creeping back through the stoker and escaping into the house during mild weather when coal is being fired slowly. The bin-feed stokers, of course, save the labor of shoveling coal into a hopper.

Stokers may be installed at the front, side, or rear of the furnace or boiler. Leave space for servicing the stoker and for cleaning the furnace. There is likely to be considerable fly ash (fine powdery ash) that collects on horizontal surfaces. Furnaces and boilers with horizontal heating surfaces will require frequent cleaning.

Oil

Oil as a fuel for heating is very popular, especially in urban areas. It requires little space for storing and no handling, and it leaves no ash. Electricity is needed with nearly all oil burners, and power outages, although usually of short duration, may be frequent and long enough to cause considerable discomfort.

Three grades of fuel oil are used for home heating. No. 1 is the lightest and is slightly more expensive than the others; Nos. 2 and 3 are the same price and often can be used interchangeably. The name plate or guide book that comes with the oil burner tells what grade oil should be used. In general, No. 1 oil is used in pot-type burners whereas Nos. 2 and 3 are used in both gun- and rotary-type burners.

To obtain best results the burner must be properly adjusted. This can be done only by one who has the proper instruments for testing flue gases and knows how to make the necessary adjustments.

Oil burners.—Oil burners are of two types: vaporizing and atomizing. Vaporizing burners premix the air and oil vapor. The pot-type burner (fig. 20) is vaporizing. It consists of a pot containing a pool of oil. An automatic valve regulates the amount of oil in the pot. Heat from the flame

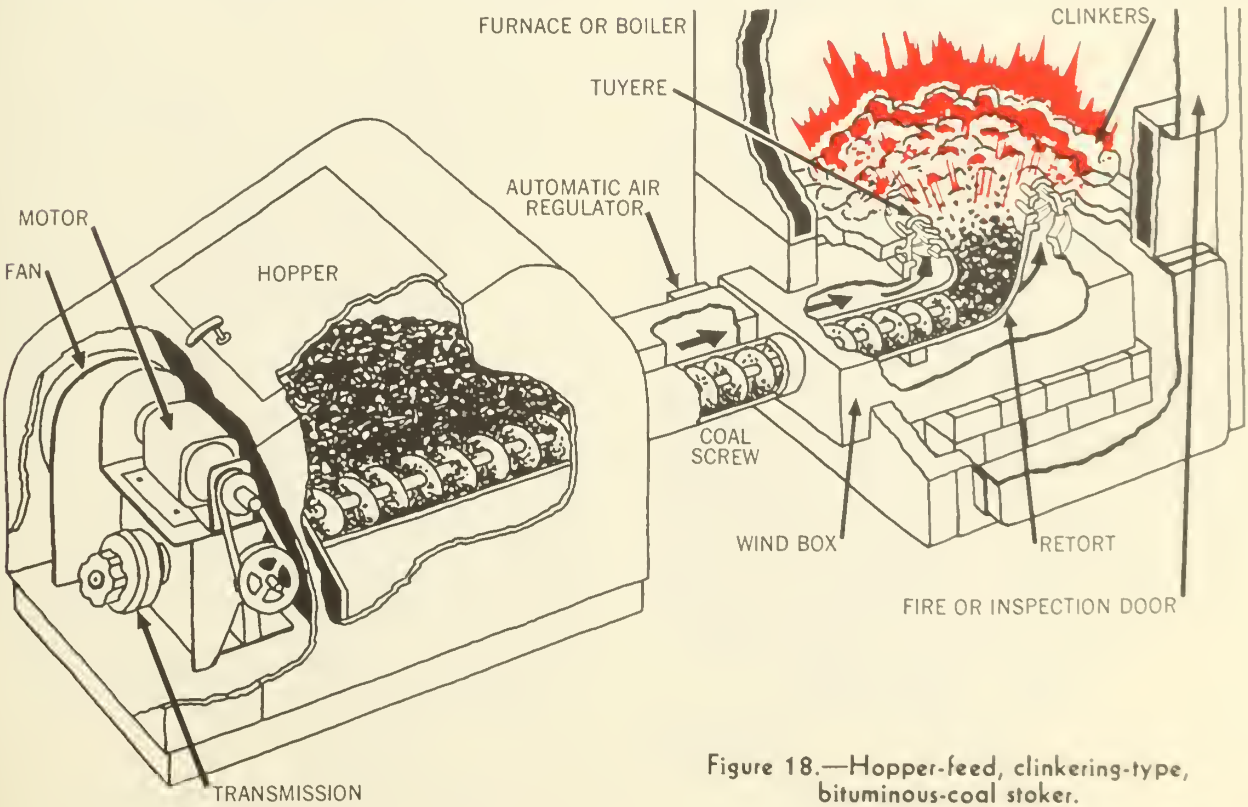

Figure 18.—Hopper-feed, clinkering-type, bituminous-coal stoker.

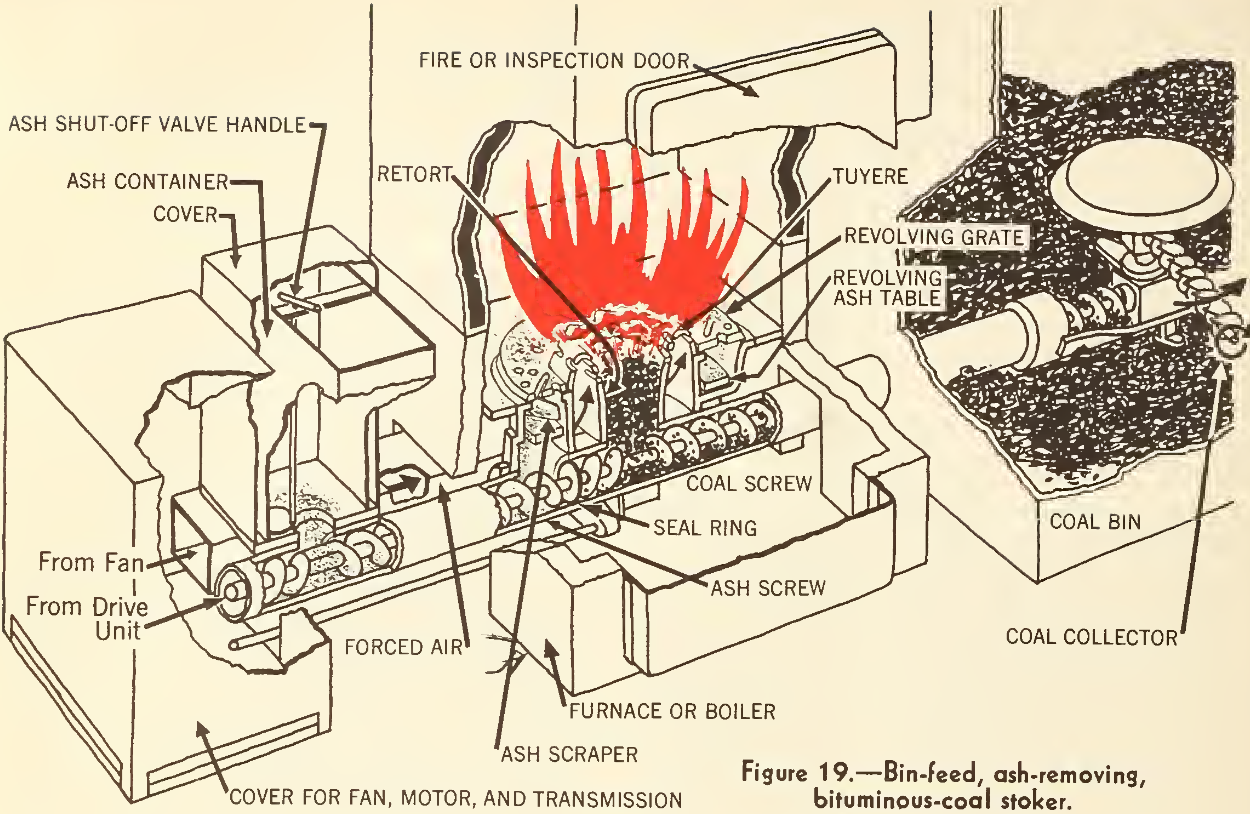

Figure 19.—Bin-feed, ash-removing, bituminous-coal stoker.

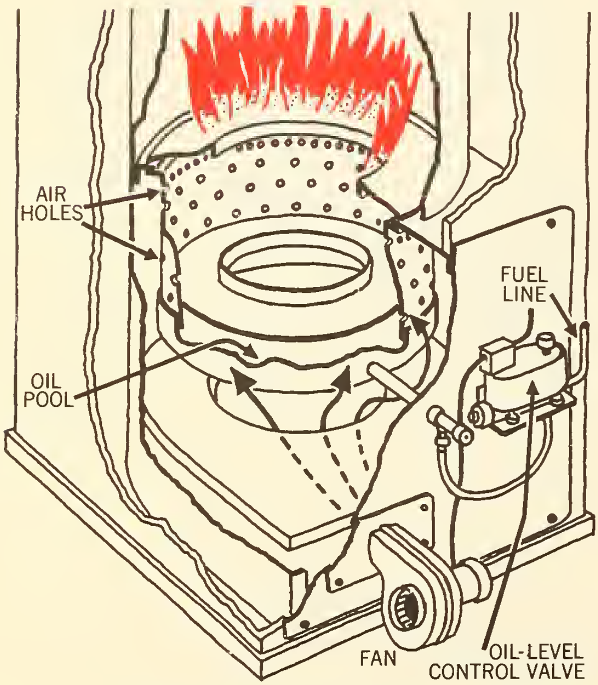

Figure 20.—Pot-type oil burner.

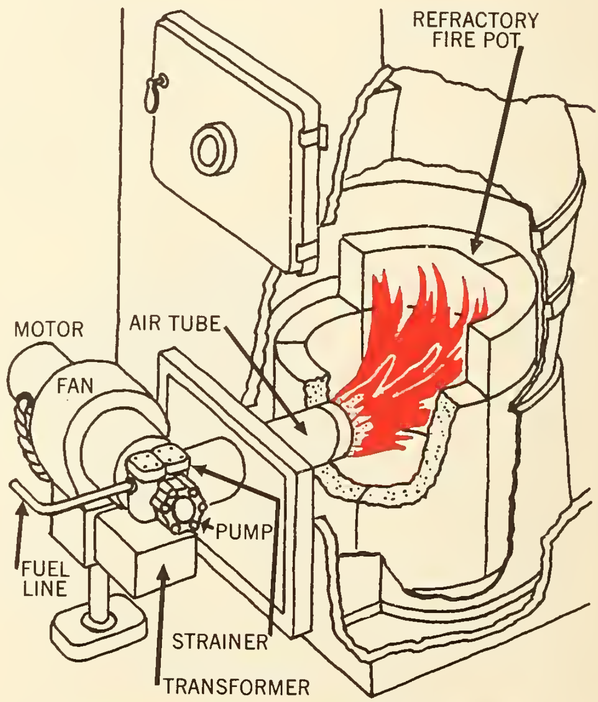

Figure 21.—Gun-type oil burner.

vaporizes the oil. Air enters just above the pool of oil either by natural draft or by a small fan. Both fuel and air must be carefully adjusted for a clean, sootless flame. A pilot flame ignites the oil pot when heat is required. There are few moving parts and operation is quiet.

Atomizing burners are of two general types: Gun, or pressure, and rotary. The pressure-type burner (fig. 21) has a pump that forces the oil through a special atomizing nozzle. Air is blown into the oil fog by a fan. The mixture is ignited by an electric spark. The burning is done in a refractory fire pot.

There has been developed recently a new type of oil-burner nozzle designed to mix the air and oil thoroughly inside the high-pressure gun tube. It is claimed to be especially efficient in using the air supplied for burning, so that much less air is required. With less heated air going up the chimney more heat is available for the house.

The rotary oil burner for house heating (fig. 22) consists of a vertical motor with a hollow shaft. The upper end of the shaft carries a fan and a set of tubes bent at right angles to the motor shaft. Centrifugal action lifts the fuel and throws it against a circle of metal vanes. There is a refractory hearth between the motor and the flame. This type of burner is set inside the combustion chamber and is less accessible for servicing but it occupies less floor space than pressure-type burners. The fuel mixture is ignited by an electric spark.

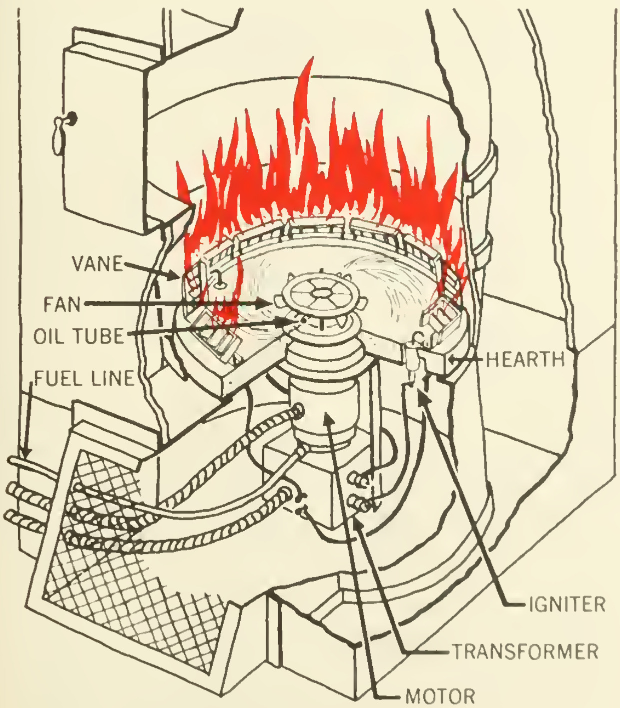

Figure 22.—Rotary oil burner.

Gas

Gas is used in many urban homes and in some rural areas. It is supplied at low pressure to a burner head (fig. 23) where it is mixed with the right amount of air for combustion. A draft hood is placed in the vent pipe to reduce excess draft and prevent gusts of air from coming down the chimney and putting out the flame.

The room thermostat controls the gas valve. A pilot is lighted at the beginning of the heating season and burns until shut off when heat is no longer required. A safety thermostat element stands guard over the pilot light at all times, because if it should go out it is absolutely essential to keep the gas valve from opening. Should the pilot light

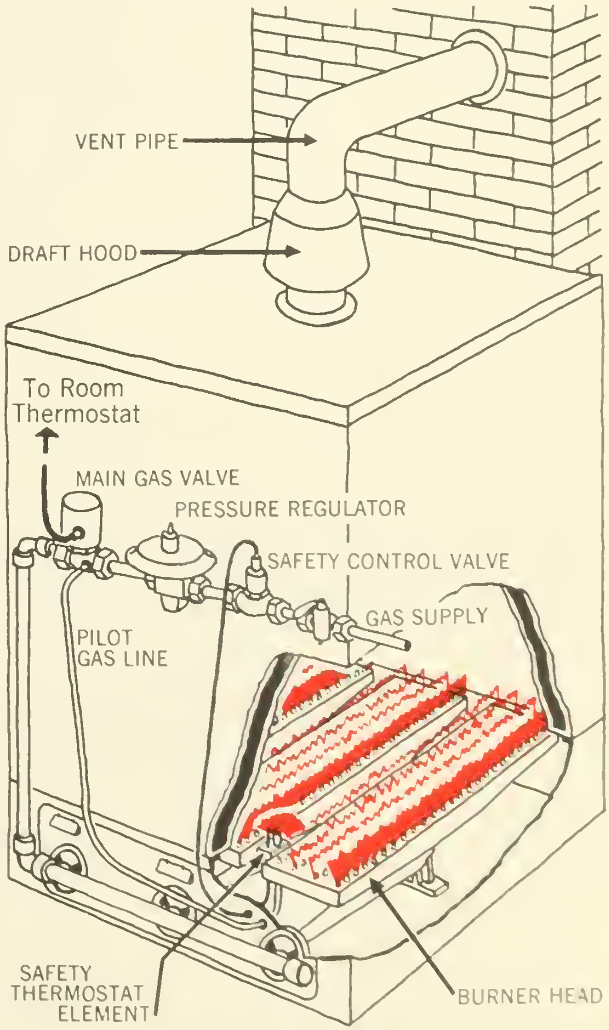

Figure 23.—Gas burner.

go out the safety thermostat element will close the main valve or a safety control valve. No gas can then escape into the room. Be sure the pilot lights of all automatic gas-burning appliances are equipped with this safety device.

Three kinds of gas are used: Manufactured gas, natural gas, and bottled gas. Bottled gas (butane, propane or a combination), is sometimes called L. P. (liquid petroleum) gas. Different gases have different heat values when burned. A burner adjusted for one gas must be readjusted when used with either of the others. Natural gas contains around 1,100 B. t. u. per cubic foot, manufactured gas around 600, and bottled gas around 3,000.

Conversion gas burners may be used in boilers and furnaces designed for coal if they have adequate heating surface. Furnaces must be properly gas tight. The installation of conversion burners, as well as all other gas-burner installations and adjustments, should be made by competent, experienced heating contractors following closely the manufacturer's instructions. Gas-burning equipment should bear the seal of approval of the American Gas Association.

Vent gas-burning equipment to the outdoors. Keep chimneys and smoke pipes free from leaks. Connect all electrical controls for gas-burning equipment on a separate switch so that in case of trouble that circuit can be broken. Have gas-burning equipment cleaned, inspected, and correctly adjusted each year.

Bottled gas is heavier than air. Unless any gas that may by chance leak into the basement can flow out to a lower level through a vent at the floor level, there is danger of explosion. When bottled gas is used, make sure that the safety control valve is so placed that it shuts off the gas to the pilot when it goes out as well as to the burner.

Electricity

Electricity heats directly in the familiar radiant heater often used for extra warmth in the bathroom. In this type of heater electricity passes through a resistance element that is placed in a reflector. Some electric heaters also have small fans to blow air past the elements and into the room. Another type of electric heater is a resistance unit immersed in a steel water column radiator. Electricity used in these resistance units generates 3,412 B. t. u. per kilowatt-hour. The conversion from electric energy to heat energy is 100 percent efficient.

A new way of using electricity for heating a whole house is reverse-cycle refrigeration. In applications of this principle the electricity is not used as the source of heat but to power equipment that will transfer heat from an outside source, such as well water or outdoor air, to the space to be heated. The machine for doing this, called the heat pump, uses an evaporator, condenser, and compressor somewhat like those of a refrigeration system.

Just as an electric refrigerator unit takes heat from the food inside the box and pumps it at a higher temperature to the air in the kitchen, a larger refrigerating system can take heat from well water or outdoor air at a low temperature, (50° F., for example) and deliver it to a warm-air circulating system at about 120°. A kilowatt-hour of electric energy can move more heat than it can generate directly.

Some heat-pump installations use the same plant to heat the building in winter and cool it in summer. There must be a great deal of practical experience with the heat pump under a wide variety of conditions before it can be generally recommended.

Automatic Controls

If the heating plant is the heart of the heating system, then the automatic controls are its brain and nerves. Each type of heating plant requires special features in its control system, but even simple control systems should include high-limit controls to prevent overheating.

The high-limit control, which is usually a furnace or boiler thermostat, shuts down the fire before the furnace or boiler becomes dangerously or wastefully hot. If steam or vapor is used, the limit controls respond to pressure in the boiler. The manufacturer of the equipment usually recommends the setting of limit controls.

Ordinarily high-limit controls are set just high enough to insure heating without overshooting the desired temperature. In a forced warm-air or forced hot-water system, the high-limit controls are usually set to start the fan or pump circulating when the furnace or boiler warms up and stop it when the heating plant cools down. The high-

limit controls can be adjusted to suit weather conditions.

Essentially, the room thermostat tells the furnace or boiler what to do to keep the temperature right. Room thermostats are sometimes equipped with timing devices to change automatically the temperature demanded at night and in the morning. The temperature of each setting and the times of making the changes are all adjustable.

Other controls insure that all operations take place in the right order. The electric current needed to operate such devices as stokers, oil burners, and circulator pumps is often too heavy for simple thermostats; so relays are added. The relay is a magnetic switch that operates on a small current and has contacts heavy enough to handle the current for the oil-burner motor and the ignition transformer.

Since the thermostat is responsible for control of the house temperature, it must be in the right place—which is usually on an inside wall. Do not put it near a door to the outside, at the foot of an

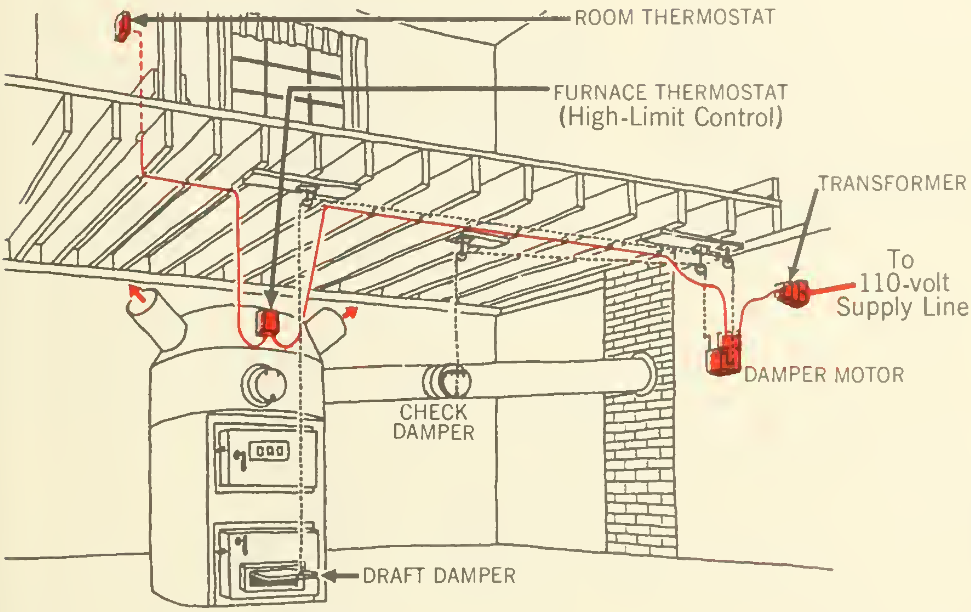

Figure 24.—Controls for hand-fired coal burner shown with gravity warm-air system.

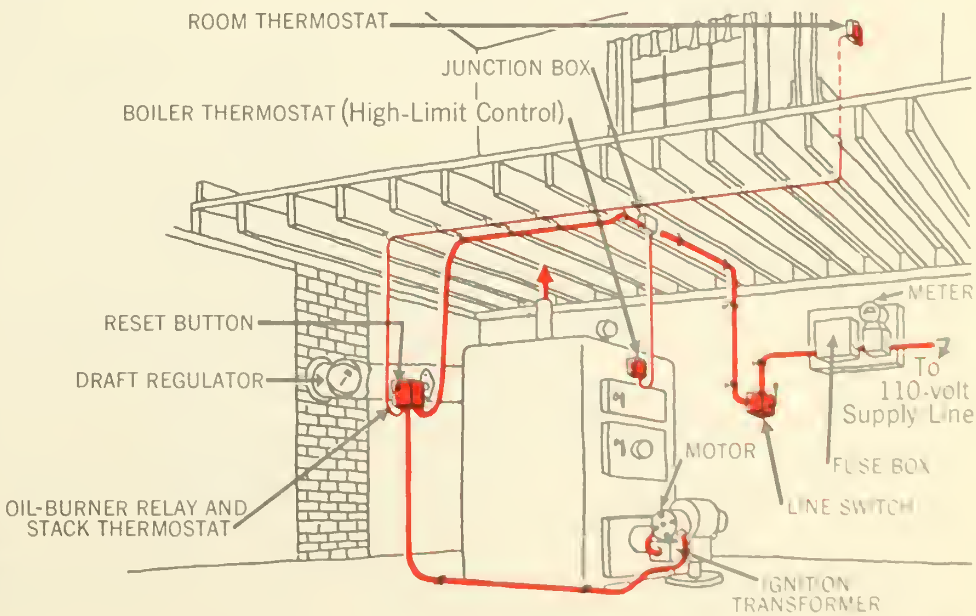

Figure 25.—Controls for atomizing oil burner shown with gravity hot-water system.

open stairway, or above a heat register, radio, or lamp. Check it for accuracy with a good thermometer.

Thermostats are either single throw or double throw. The single throw allows the contact points to touch only under one condition, either when the temperature is too high or else when it is too low. In the double throw the contact points touch when the temperature is too high and also when it is too low.

Hand-Fired Coal-Burner Controls

In any gravity system with a hand-fired furnace or boiler, the controls have only to open and close the draft and check dampers. If the damper motor is the type that requires electricity to operate in each direction, a double-throw thermostat is used. Some damper motors operate in one direction by electricity and in the other direction by springs. Single-throw thermostats are used with these motors.

Damper motors have two crank arms so arranged that when one pulls its chain to open the draft damper, the other slacks off its chain to let the check damper close. When the temperature is high enough the thermostat swings to the opposite contact point and allows electric current to flow through the damper motor, driving it in the opposite direction to close the draft damper and open the check damper. A simple control system for a hand-fired furnace with a gravity warm-air heating system is shown in figure 24. A furnace thermostat on the bonnet acts as high-limit control should the room thermostat continue to demand heat when the furnace is dangerously hot.

Oil-Burner Controls

The oil-burner controls allow electricity to pass through the motor and ignition transformer and shut them off in the right order. They also stop the motor if the oil does not ignite or if the flame goes out. This is done by means of a stack thermostat built into the relay. The whole assembly can be mounted on the smoke pipe near the furnace or boiler, or the relay may be mounted on a wall.

Without the protection of the stack thermostat a gun- or rotary-type burner, if it failed to ignite, could flood the basement with oil. With it, the relay lets the motor run only a short time if the oil fails to ignite; then it opens the motor circuit and keeps it open until reset by hand. If your burner will not operate until reset by hand, push the reset button a couple of times. If the burner still does not go on, have the serviceman investigate. Satisfactory controls for an oil burner with a gravity hot-water system are shown in figure 25. A boiler thermostat acts as high-limit control should the water in the boiler get too hot.

Stoker-Fired Coal-Burner Controls

The control system for a coal stoker is much like that for an oil burner, but an automatic timer is usually added to operate the stoker for a few minutes every hour or half hour to keep the fire alive. The timer is often built into the stoker relay.

The stack thermostat is not always used, but in communities where electric power outages are likely to be long enough to let the fire go out, a stack thermostat or other control device is needed to keep the stoker from filling the cold fire pot with coal when the electricity comes on again. Sometimes a light-sensitive electronic device such as an electric eye is used. In the stoker-control set-up (fig. 26), which is for a forced warm-air system, a furnace thermostat acts as high-limit and fan control.

Gas-Burner Controls

Controls for the gas burner are so much a part of the burner itself that they have been described and illustrated under gas burners on pages 17 and 18.

Heating-System Controls

There are many ways of controlling warm-air, hot-water, or steam-heat distribution systems besides those suggested in the burner-control pictures. If the furnace or boiler heats domestic water, more controls are needed. Controls for a stoker-fired boiler for forced hot-water heat and year-round domestic hot water are shown in figure 27.

If water is heated for domestic purposes, the boiler must stay hot. In the installation shown, the control system must operate both the burner and the circulator when the room thermostat calls for heat, but it must operate the burner alone when only the boiler thermostat demands heat. Since the stoker relay cannot at one time operate the burner alone and at another time operate both the burner and circulator, an additional relay is needed.

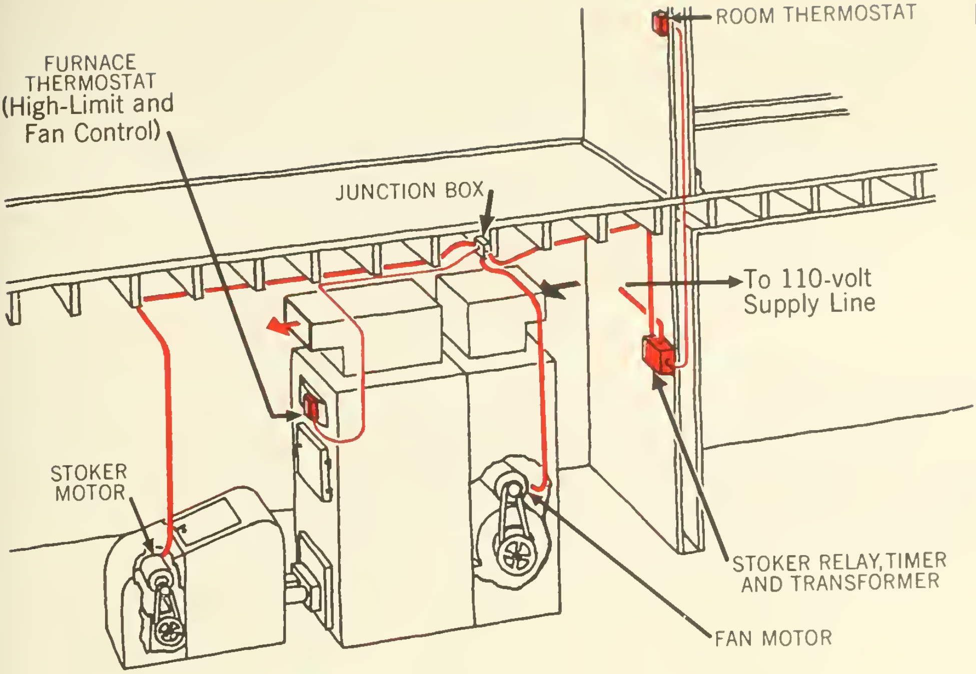

Figure 26.—Controls for stoker-fired coal burner shown with forced warm-air system.

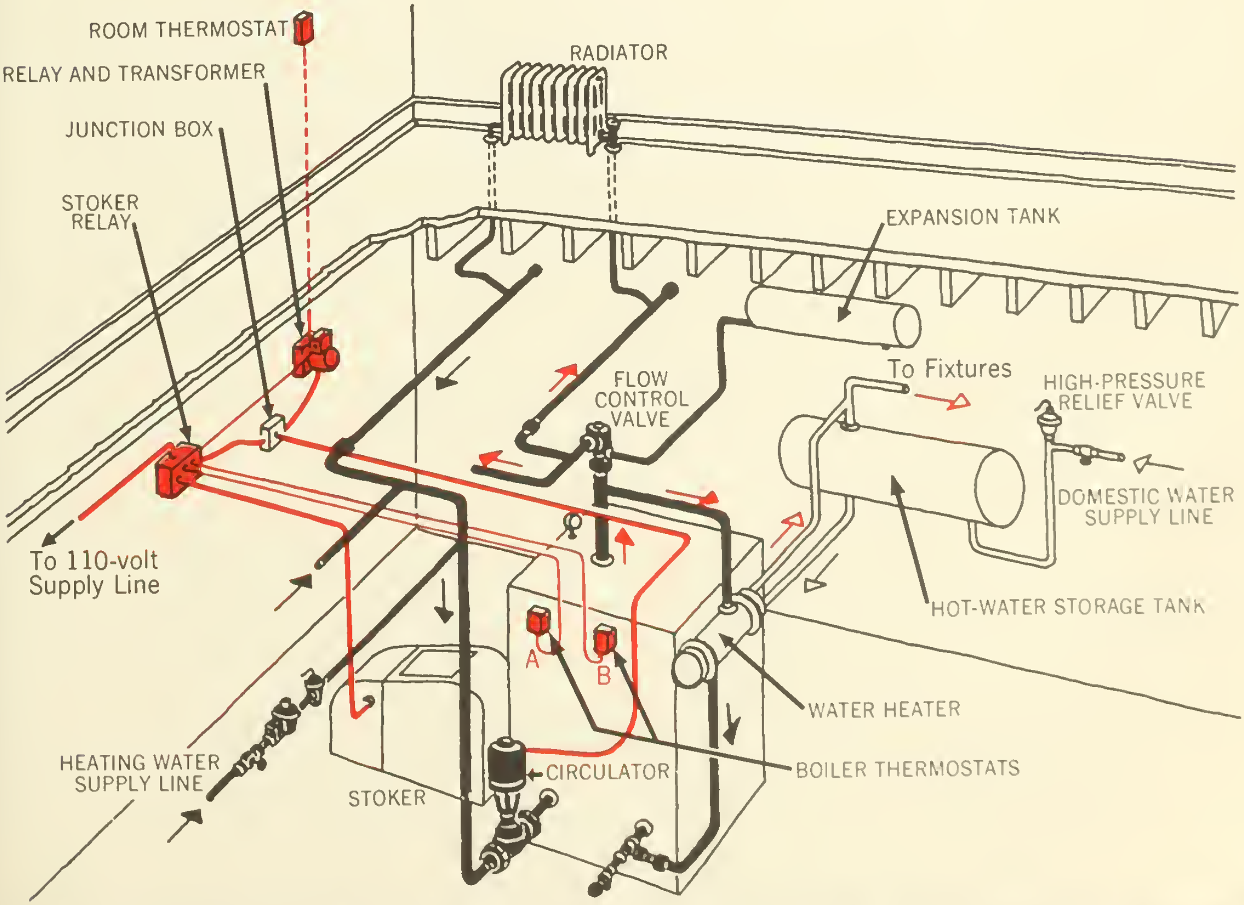

Figure 27.—Controls for forced hot-water system with year-round domestic hot-water hook-up, shown with stoker-fired coal burner.

Boiler thermostat "A" maintains the boiler temperature and boiler thermostat "B" acts as a high-limit control. If the boiler temperature gets too low to heat domestic water, thermostat "A" starts the burner independently of the room thermostat. If during any operation the boiler should get too hot, thermostat "B" will stop the burner. If for any reason the boiler reaches a still higher temperature, thermostat "B" will start the circulator to carry away the excess heat even if the house is already warm.

In some new installations of forced hot-water systems, especially with domestic-water hook-ups, a mixing valve is used. The water temperature of the boiler is maintained at some high fixed value, say 200° F. Only a portion of this high-temperature water is circulated through the heating system. Some of the water flowing through the radiators bypasses the boiler. The amount of hot water admitted is controlled by a differential thermostat operating on the difference between outdoor and indoor temperatures. This installation is more expensive than the kind described above, but it responds almost immediately to demands; and while it cannot anticipate temperature changes, it is in a measure regulated by outside temperatures, which do change earlier than those indoors.

The flow of hot water to each part of a building can be separately controlled. This zoning—maintaining rooms or parts of the building at different desired temperatures—is seldom needed in small, one-family houses.

Fuel savings help to offset the initial cost of the more elaborate control systems.

Check for Safety and Efficiency

1. *Installation*

- Heating plant of correct size ■
- Heating plant on solid, level, fireproof foundation ■
- Electric heating equipment grounded ■
- Heating plant safe distance from wall ■
- All clearances agreed to by fire-insurance company ■
- Floor under stove, circulator, or space heater protected by pad of sheet metal and asbestos ■
- Smoke pipes direct from heating plant to chimney ■
- Smoke pipes rigidly supported ■
- Ventilated sleeve around smoke pipe where it passes through walls and ceilings ■

2. *Maintenance*

- Smoke pipe and chimney clean and free from leaks ■
- Fuel tanks and fuel lines free from leaks ■

3. *Yearly inspection*

- Furnace or boiler cleaned and repaired before heating season starts ■
- Coal stoker, oil burner, or gas burner checked and adjusted before heating season starts ■

4. *Safety precautions*

- Space around heating plant kept free from trash ■
- No clothes dried near heating equipment ■
- Ashes collected in metal containers ■
- Fireplace screens used regularly ■

5. *Economy recommendations*

- House kept at lowest temperature good health and comfort permit ■
- Fireplace damper closed when fireplace not in use ■
- House insulated and equipped with storm doors and windows ■
- No leaks in hot-water faucets ■
- Boiler and hot-water tank insulated ■
- Unused rooms closed off ■

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